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GB 1597842 GB 1445977 EP A2 0074630
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(58) Field of search
C1M
H1N

(54) **Coatings for contacts of a touch probe**

(57) A probe for detecting contact with an object such as a workpiece includes a switch assembly having one or more point contacts 20,22 therein which deveop a change in electrical resistance when the probe stylus moves from its rest position upon contacting the object. The contact members are coated with a homogeneous, chemically inert, and electrically conductive material to maintain precise mechanical repeatability and consistent electrical characteristics of the probe. Preferably, the coating material is selected from the group of titanium nitride and titanium carbide where the contacts are made of tungsten carbide.

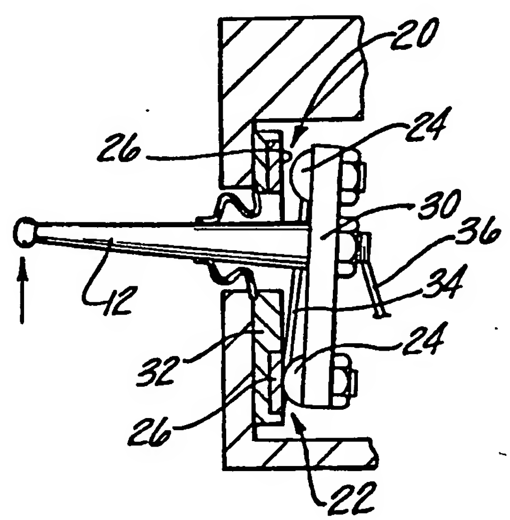

Fig-3

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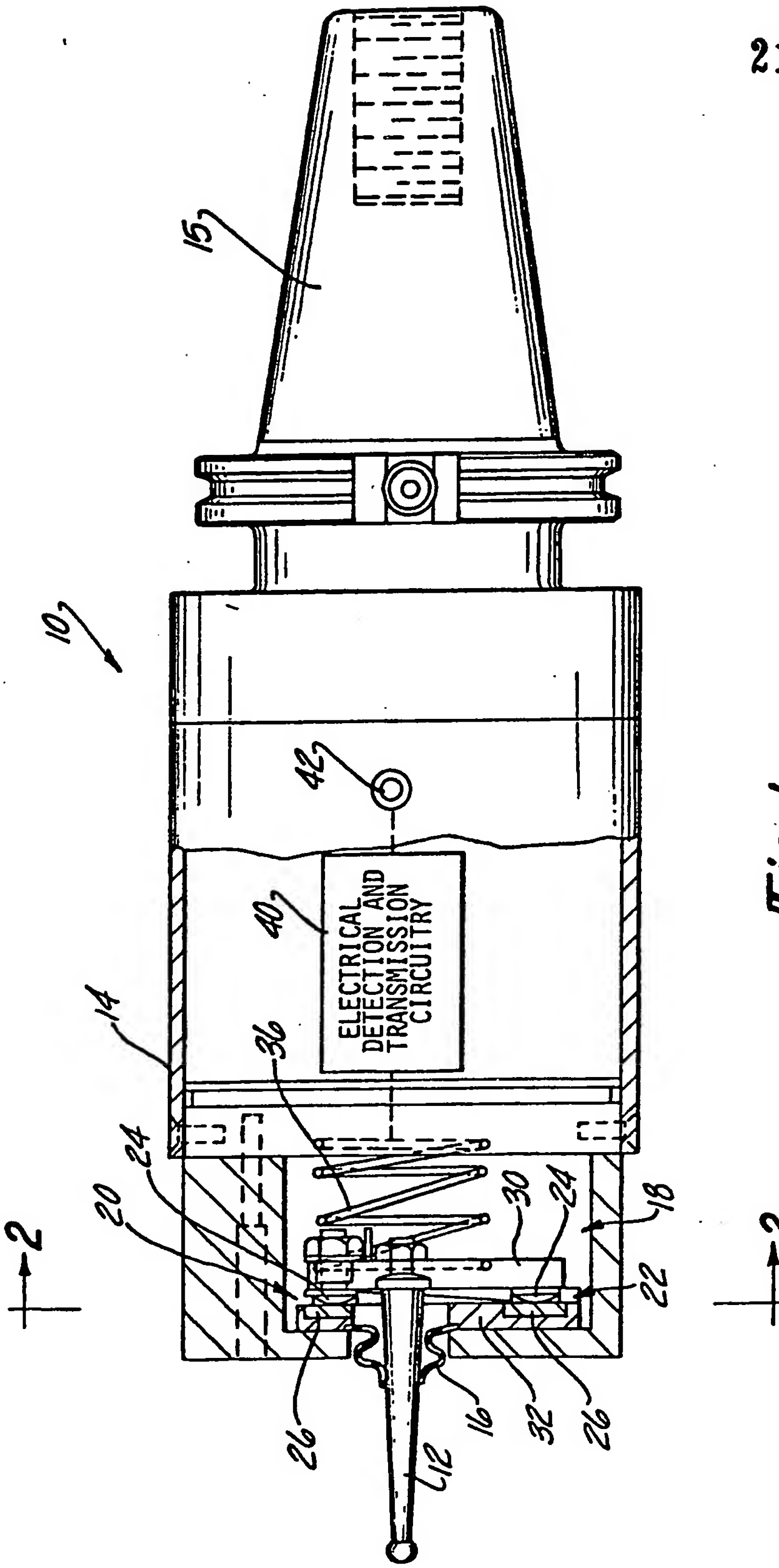

Fig-1

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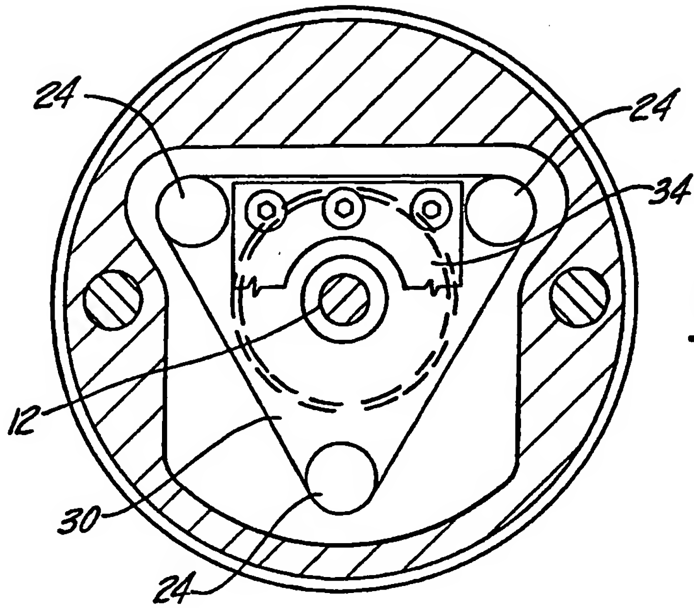

Fig-2

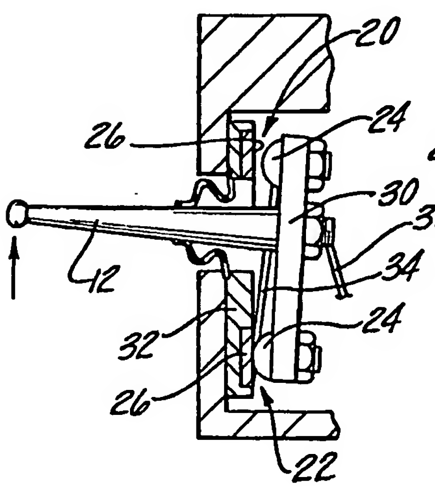

Fig-3

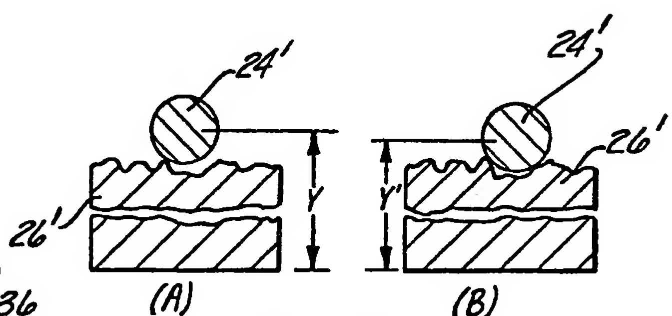

Fig-4

PRIOR ART

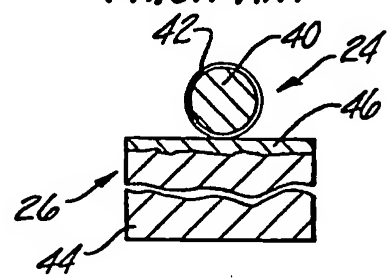

Fig-5

SPECIFICATION

Coatings for contacts of a touch probe

Technical Field

This invention relates to probes for detecting contact with an object such as a workpiece. More particularly, the invention involves the construction of the contacts used in such probes that develop a change in electrical characteristics as a result of the probe touching the object.

Background Art

Automatic machining systems and coordinate measuring systems require a precise means for locating surfaces on workpieces. One method of such measurement is to utilize a so-called "touch probe" in which a stylus is moved into a position where it touches the surface resulting in a movement of the stylus from its rest position. The probe includes one or more point contacts whose electrical characteristics, generally resistance, are changed as a result of movement of the stylus. This change in electrical characteristic is typically made by opening the point contacts and detecting the resultant change in electrical resistance by suitable electrical circuitry. The signal from the probe is used in conjunction with a determination of the X, Y and Z axes location of the table or machine spindle to calculate the position of the inspected workpiece surface.

The usefulness of these touch probes depends upon their extreme repeatability. It is often desirable to provide a probe that is capable of repeating its measurement to within about one micron or less. In other words, if the probe is used to make several measurements on the same workpiece surface, the calculated position thereof cannot deviate more than about one micron.

In order to provide and maintain touch probes with this kind of repeatability over a period of time there are two basic requirements. The first is that the contacts must return to exactly the same position whenever external contact force is removed from the probe stylus. This requirement is referred to as mechanical positional repeatability. The second requirement is the electrical resistance between the contacts remains constant whenever the stylus returns substantially to its rest position.

The mechanical repeatability requirement generally necessitates the use of one or more point contacts. Touch probes of the assignee of the present invention have utilized a spherical surface against a flat surface to define the point contacts (see, e.g. U.S. Serial No. 388,187, filed June 14, 1982 by Cusack entitled "Touch Probe"). Other types of touch probes utilize a spherical surface trapped by two converging spherical or flat surfaces (see, e.g. U.S. patent Nos. 4,155,171 to McMurtry; 4,270,275 to McMurtry and 4,301,338 to McMurtry).

Cemented carbide is typically used as the material for the contacts. Unfortunately, the grains of the binder metal do not have exactly the same electrical characteristics as the carbide particles. Thus, the electrical characteristics thereof may change if the location of the point contact changes from an area of binder metal to that of carbide. In addition, the binder metal has a tendency to oxidize creating an uneven surface even after polishing. The oxidation rate is further increased when electrical current passes through the contacts. Whether the surface roughness is created by oxidation or otherwise, it affects the mechanical repeatability of the probes using these contacts.

In an effort to overcome these problems the contacts have, in the past, been covered with a neutral pH value oil such as baby oil, mineral oil or the like. However, the oil has a tendency to become displaced from the contacts after a period of use so that the contacts again become exposed to the air and other sources of contamination. In addition,the oil is somewhat messy and can also flow over other parts in the probe. Consequently, this approach has not been entirely satisfactory in overcoming the problems noted above.

Summary of the Invention

Pursuant to the present invention the contacts are coated with a homogeneous, chemically inert electrically conductive material. Preferably, the contacts are made of tungsten carbide and the coating material is selected from the group of titanium nitride and titanium carbide. These coatings are harder than the tungsten carbide and compatible therewith. Since the coating material is inert the contacts do not corrode and the aforementioned problems with mechanical repeatability are avoided. In addition, the homogeneous nature of the coatings maintain consistent electrical resistance characteristics for the contacts even after prolonged usage of the probes. Consequently, the problems associated with the prior art approach are substantially eliminated while at the same time avoiding the undesirable side effects resulting from the conventional practice of applying oil to the contacts.

Brief Description of the Drawing

The various advantages of the present invention will become apparent to those skilled in the art upon reading the following specification and by reference to the drawings in which:

FIGURE 1 is a plan view in partial cross section of a touch probe utilizing the teachings of the present invention;

FIGURE 2 is a cross-sectional view along

the lines 2-2 of FIGURE 1;

FIGURE 3 is a partial cross-sectional view similar to that of FIGURE 1 depicting the probe stylus in a displaced position under a contact force;

FIGURE 4 (A-B) are enlarged cross-sectional views of two probe contact members of the PRIOR ART; and

FIGURE 5 is a cross-sectional view showing contact members made in accordance with the preferred embodiment of this invention.

Description of the Preferred Embodiment

FIGURES 1 and 3 illustrate a touch probe 10 of the type in which the improvements of the present invention find particular utility. The details of the construction of probe 10 are disclosed in U.S. Serial No. 388,187 filed June 14, 1982 and assigned to the assignee of the instant invention. Therefore, only those details necessary to an understanding of the present invention will be described.

Probe 10 includes a stylus 12 projecting from one end of housing 14 through an aperture therein. The probe 10 also includes an adapter section 15 which may, for example, include a machine tool industry standard taper which is configured for receipt in a complimentary socket of a machine tool spindle. A variety of other adapter configurations is well within the knowledge of the skilled practioner and known in the art.

A diaphragm 16 surrounds stylus 12 in the area of the aperture to protect the internal components from contamination. The rearward end of stylus 12 is connected to a switch assembly generally designated by the numeral 18. The purpose of switch assembly 18 is to change an electrical characteristic whenever the stylus 12 contacts an object and moves from its rest position, i.e. when the stylus 12 contacts an object. In the illustrated embodiment, this is accomplished by way of three of point contacts, two of them bearing the reference numerals 20 and 22. Each point contact is defined by a first electrically conductive member having a spherical surface and a second electrically conductive member opposing the first. In this embodiment, the contacts 20 and 22 are each defined by a ball 24 and a pad 26. The balls 24 are affixed to a pivot plate 30 connected to the rearward end of stylus 12. The pads 26, on the other hand, are mounted to a fixed reference surface provided by member 32.

A reed spring 34 is connected at one end to pivot plate 30 and at another end to member 32. The purpose of reed spring 34 is to urge the contacts together in the absence of contact force being exerted on stylus 12 as shown in FIGURE 1. A spring 36 may also be provided to give additional bias force parallel to the longitudinal axis of stylus 12 thereby urging plate 30 and member 32 into a rest position via engagement of the contacts.

As shown in FIGURE 3, deflection of the stylus 12 causes deflection of pivot plate 30 thereby displacing one of the contacts depending upon the direction of stylus movement. In FIGURE 3, contact 20 is shown displaced thereby opening the electrical connection defined by ball 24 and pad 26. This change in electrical characteristic can be detected in a variety of ways well within the knowledge of those skilled in the art. One such technique is disclosed in U.S. Serial No. 259,257 file April 30, 1981 and assigned to the same assignee as the present invention. Basically, circuitry 40 is used to detect the opening of one of the contacts and initiate the transmission of an optical signal via infrared light emitting diode 42. The signal from diode 42 can be used by a machine controller to calculate the position of the probe and therefore the location of the surface that it contacted. The above-mentioned applications are hereby incorporated by reference. It should be understood, however, that various other probe contact arrangements and detecting schemes can also be utilized.

It can be appreciated that the accuracy of this general approach requires mechanical repeatability and consistent electrical charactersitcs developed between the contacts. Reference to FIGURE 4 will help in the understanding of some of the problems with the contact construction of the prior art. In FIGURE 4 the pad and ball making up the point contact of the prior art design bear a prime superscript. The pad 26′ is shown in exaggerated manner with uneven surface. As noted above, this uneven surface has a tendency to develop after a period of use of the probe due to such things as oxidation and the like. If the ball 24′ contacts a peak in the surface of pad 26′ as shown in FIGURE 4A, then the stylus 12 will be in a given rest position which is a function of the distance Y. If the ball 24′ is contacting a carbide particle making up the peak of the pad 26′ surface there will be a given electrical resistance developed therebetween. FIGURE 4B illustrates a situation in which the ball 24′ has fallen into a valley in the uneven surface of pad 26′. In such situations the rest position of stylus 12 will be different from that shown in FIGURE 4A. This is represented by the difference in distances Y and Y′. Accordingly, the probe 10 cannot repeat the same measurement with the same results thereby disturbing its accuracy. Additionally, if the ball 24 is contacting dissimilar materials such as a binder metal then the electrical characteristics will also be different thereby further increasing the potential for inaccurate measurements.

Pursuant to the present invention, these and other problems are solved by coating the contact members with a homogeneous, chemically inert, electrically conductive material. preferably, the bodies of the contact members are made of cemented carbides, for

example fine tungsten carbide particles bonded or cemented with a tough, comparatively soft binder metal, such as cobalt. It is to be understood that the term "cemented carbide" as used herein may, in addition to tungsten carbide, include commercially available materials in which the tungsten carbide is frequently supplemented or substituted by the carbides of titanium, tantalum, niobuim, chromium, vanadium, molybdenum or hafnium, independently or in combination, while the cobalt binder may similarly be alloyed with, or substituted by, nickel or nickel-molybdenum. One type of cemented carbide found suitable for the purposes of the invention is grade VC-2, commercially available from The Valeron Corporation, Troy, Michigan.

Preferably, the cemented carbide contact bodies are coated with a layer selected from the group of titanium nitride and titanium carbide. Titanium nitride is preferred because of its better electrical conductive characterisitics. As shown in FIGURE 5 the body 40 of ball contact 24 includes coating 42 and the body 44 of pad 26 includes coating 46. Coatings 42 and 46 are characterized by extremely hard conductive surfaces exhibiting a Rockwell hardness in the C scale. The coatings 42 and 46 resist oxidation and thereby retain their smooth surface configuration. In addition, the homogeneity of the coatings insures consistent electrical resistance characteristics therebetween.

In producing the contact members the tungsten carbide bodies are preferably lapped to about 95% of their desired ultimate surface finish. For example, it is preferable to have an ultimate surface finish of about 2-3 RMS and, therefore, the carbide bodies are lapped to about a 5 RMS finish. The contact bodies are then coated with a layer about 2-3 microns in thickness. The bodies are preferably coated using a chemical or physical vapor deposition process. After the coatings have been applied the coated contact members can be lapped down to their final finish, if necessary. By using a physical vapor deposition process this latter lapping step may be eliminated.

Those skilled in the art can now appreciate the present invention may provide probes of these types with exceedingly long useful lives by fulfilling the dual requirements of mechanical repeatability and consistent electrical characterisitics for the contacts. It eliminates the conventional use of oil in the probe, an approach which has not proven to be entirely satisffactory in the long run. It should be understood that while this invention was described in connection with specific examples thereof, various modifications will become apparent to those skilled in the art after a study of the specification, drawings and following claims.

CLAIMS

1. In a probe for detecting contact with an object, said probe including a stylus projecting from one end thereof having a tip adapted to touch the object resulting in movement of the stylus from a rest, position, and switch assembly means connected to the other end of the stylus for developing a change in electrical characteristic when the stylus moves from its rest position, the improvement wherein:

said switch assembly means includes at least one point contact defined by a first electrically conductive member having a non-planar surface and a second electrically conductive member having a surface located generally opposite to that of the non-planar surface of the first member, one of the members being movable with the stylus and the other member being fixed, and said surfaces of the members being coated with a homogeneous, chemically inert, electrically conductive coating material to thereby maintain precise mechanical repeatability and consistent electrical characteristics of the probe.

2. The improvement of claim 1 wherein said members have bodies comprising cemented carbide particles in a binder metal and said coating material is selected from the group of titanium nitride and titanium carbide.

3. The improvement of claim 2 wherein one member is in the shape of a ball and the surface of the other member is generally flat.

4. The improvement of claim 2 wherein said members are coated with said coating material to a thickness of about 2-3 microns.

5. A method of making contact members for use in a touch probe, said method comprising:

vapor depositing a coating of titanium nitride or titanium carbide onto bodies made of cemented carbide.

6. A method of making contact members for use in a touch probe, said method comprising:

vapor depositing a homogeneous, chemically inert, electrically conductive coating material onto electrically conductive bodies.

7. A method of making contact members for use in a touch probe; such method being substantially as herein described with reference to the accompanying drawings.

8. A probe for detecting contact with an object, such probe being constructed and arranged substantially as herein described with reference to and as illustrated in the accompanying drawings.

9. A switch assembly for a probe, such switch assembly being constructed and arranged to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

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